

10/10/96
20/10/96
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Semi-Annual Report on NASA Grant NAGW5-1097:
MAMI:
Modeling of the Magnetosphere-Ionosphere-Atmosphere System.
1 May 1995 to 31 October 1996

- Software development to access and analyze level 1 UVI data has been developed and installed in close collaboration with the UVI team members. We have developed image processing software to transform UVI images into geographic and geomagnetic coordinate systems. We have developed procedures and provided software for separating dayglow and auroral brightness in UVI images. We also have software to interpret the images and ratios of images in different wavelength regions in terms of energy flux and characteristic energy of precipitating electrons.
- The period from 17:30 UT on 19 May, 1996, to 02:30 UT on 20 May, 1996 has been selected as a study period by the ground-based and theory teams. We have obtained data from various sources and started our analysis of the auroral activity during the indicated period. Details of this analysis have been presented at team meetings, and have been submitted for presentation at the AGU Fall meeting (abstract is appended). A special web page was developed and is maintained at URL

http://odin.gi.alaska.edu/lumm/May_19_20/top.html.

An analysis using the AMIE technique has been initiated and the necessary data for this period have been assembled.

- Local comparisons between *in situ* auroral flux and energy observations from DMSP and NOAA satellites and UVI image derived quantities have been utilized to assist the UVI team in validating the instrument calibration.
- A paper comparing the integrated hemispheric energy flux derived from UVI images into the auroral zone with the hemispheric power from NOAA satellites has been submitted to Geophysical Research Letters for publication in the upcoming special issue on ISTEP/GGS (Lummerzheim *et al.*, 1996). The abstract is appended.
- A paper comparing auroral data derived from UVI images and Sondrestrom radar observations has been prepared and submitted to Geophysical Research Letters (Doe *et al.*, 1996). This comparison addresses auroral structures at the pixel resolution of the images. The abstract is appended. Results from this study will also be presented at the Fall AGU meeting (abstract is appended).
- The UVI team meeting at the University of Washington in Seattle (2-3 May, 1996) was attended by D. Lummerzheim and M. H. Rees.
- The ISTEP/GGS Science Team Meeting held at GSFC (1-3 July, 1996) was attended by M. H. Rees and D. Lummerzheim.
- The Polar Operations Meeting held at GSFC (27-28, 1996) was attended by M. H. Rees and D. Lummerzheim.
- The home-page for MAMI on the World Wide Web at URL

<http://loke.gi.alaska.edu/mami.html>

is updated occasionally. This set of pages describes the theoretical background, modeling procedure, and gives a few examples using existing data. A recent addition (aside from

the above mentioned event page for the May 19/20, 1996 analysis period) demonstrates the separation of auroral from dayglow emissions in UVI images where the auroral zone is illuminated by the sun everywhere in the northern hemisphere. This page can be accessed at URL

<http://odin.gi.alaska.edu/lumm/UVI/sza.html>

or through links in the MAMI home page. An animation of this procedure was prepared as a "science nugget" for the ISTP/GGS project.

- Submitted papers:

D. Lummerzheim, M. Brittnacher, D. Evans, G. A. Germany, G. K. Parks, M. H. Rees, and J. F. Spann, High time resolution study of the hemispheric power carried by energetic electrons into the ionosphere during the May 19/20, 1996 auroral activity, *Geophys. Res. Lett.*, , *submitted*, 1996.

R. A. Doe, J. D. Kelly, D. Lummerzheim, M. Brittnacher, G. A. Germany, G. K. Parks, and J. F. Spann, Initial comparison of POLAR UVI and Sondrestrom IS radar estimates for auroral electron energy flux, *Geophys. Res. Lett.*, , *submitted*, 1996.

High Time Resolution Study of the Hemispheric Power Carried by Energetic Electrons into the Ionosphere During the May 19/20, 1996 Auroral Activity

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Abstract. The UVI imager on board the POLAR satellite offers the opportunity to obtain high time resolution global auroral images. The spectral resolution of the imager is sufficient to separate the auroral emission from the scattered sunlight, even when the entire auroral zone is sunlit. The energy flux of the precipitating electrons is derived from the surface brightness through the LBH-long filter. Global images which have the dayglow removed are spatially integrated to yield the total rate of energy input into the northern hemisphere. This parameter, the hemispheric power, has found much application in ionospheric modeling. It can also be derived from electron spectra measured along the track of the NOAA/TIROS satellites that are combined with average empirical auroral precipitation patterns. We show that the hemispheric power derived from the two-dimensional images represents a substantial improvement in the temporal variability of this parameter. We present an example for the period of 19/20 May 1996 by comparing the hemispheric power derived from NOAA/TIROS measurements with those derived from the UVI images.

Submitted to GRL

Initial comparison of POLAR UVI and Sondrestrom IS radar estimates for auroral electron energy flux

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Abstract. Calibrated images from the POLAR satellite ultraviolet imager (UVI) in the 165.5 to 174.5 nm portion of the N₂ Lyman-Birge-Hopfield band (LBH-long) can be used to estimate the energy flux (F_E) of auroral electrons precipitating into the high-latitude ionosphere. Similarly, electron density profiles, as measured by ground-based incoherent-scatter (IS) radar, can be used to estimate F_E and mean energy (E_0) by solving a system of linear equations relating the E -region ionization rate profile to a family of monoenergetic ion production profiles. A coordinated POLAR/IS radar experiment, designed as an initial comparison of POLAR UVI and ground-based estimates of F_E for a stable auroral arc, was executed during a POLAR apogee on May 20, 1996 at the Sondrestrom IS radar facility (lat. 66.99° N, long. 50.95° W). Reconstructed energy distributions, based on radar-measured N_e profiles, indicate an approximately 2 keV Maxwellian source with an energy flux of from 6.4 to 14 mW m⁻². LBH-long images, binned over 0.5° of latitude and 1.0° of longitude, were used to derive energy flux as well. The UVI-derived F_E time history agrees favorably with radar estimates both in absolute magnitude and in the trend for this period. This experiment suggests that reliable estimates for the precipitating electron source energy and its ionospheric response can be derived from either ground-based IS radar or POLAR UVI images during summertime conditions.

Submitted to GRL

1. Introduction

Effective application of existing assimilative electrodynamic models as space weather diagnostics will require high time resolution ionospheric input parameters from both ground-based and orbital platforms [Behnke *et al.*, 1995]. Satellite UV and visible imaging diagnostics are increasingly being used to estimate the ionospheric response to energetic auroral input beyond their traditional role in describing the global boundaries of the aurora. For example, single wavelength images from the DE-1 satellite have been used to relate UV brightness to ground-based measurements of ionospheric conductance [Robinson *et al.*, 1989]. Pairs of UV/visible images from polar orbiting satellites have been used to characterize the energetics of the precipitating electron source on the nightside [Lummerzheim *et al.*, 1991; Robinson *et al.*, 1992].

The key to successful analysis of this type is to select a pair of wavelengths that allow the extraction of both

High time resolution hemispheric power derived from POLAR imager data

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The UVI imager on board the POLAR satellite offers the opportunity to obtain high time resolution global auroral images. The spectral resolution of the imager is sufficient to separate the auroral emission from the scattered sunlight, even when the entire auroral zone is sunlit. The brightness observed by one of the filters (LBH-long) can be interpreted in terms of energy flux of the precipitating electrons. Global images which have the scattered sunlight removed can be integrated to provide the total hemispheric electron energy flux. This parameter, the hemispheric power index, has in the past found much application in ionospheric modeling. It can also be derived from {\it in situ} measurements of the electron energy flux aboard the NOAA-TIROS or DMSP satellites in combination with average auroral precipitation patterns. We show that the image data provide a substantial improvement over the {\it in situ} measurements and present an example for the period of May 19 and 20, 1996, comparing data from NOAA-TIROS with UVI images.

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Comparison of POLAR UVI and Sondrestrom IS Radar Estimates for Auroral Precipitation Energetics

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Auroral UV images from the POLAR satellite in the LBH N_2 band can be used to estimate the mean energy (ϵ_0) and energy flux (Q) of electrons precipitating into the ionosphere and, by use of an electron transport model, can be used to estimate the shape of the electron density profile ($N_e(z)$). Similarly, E -region electron density profiles, as measured by the Sondrestrom ground-based incoherent scatter (IS) radar (66.99 N Lat, 50.95 W Lon), can be used to reconstruct the source energy distribution using the deconvolution method of *Vondrak and Baron* [1976]. Such reconstructed energy distributions can be fit with analytic functions to recover estimates for ϵ_0 and Q . A coordinated POLAR UVI/Sondrestrom IS radar experiment, designed to cross-compare estimates of ϵ_0 , Q , and $N_e(z)$, was executed during a POLAR apogee on May 20, 1996. During this experiment, a stable recovery phase arc was detected in UVI LBH-short and LBH-long images, as well as in Sondrestrom elevation scans and up-B dwells. IS radar estimates for ϵ_0 and Q based on three consecutive N_e profiles (0232:50 UT to 0244:42 UT) compare well with POLAR UVI estimates, despite the somewhat coarse (0.5°) latitudinal resolution of the UVI PIXELS. POLAR UVI estimates for the shape of the N_e profile, based on the electron transport model of *Lummerzheim and Lilensten* [1994], compare favorably with IS radar $N_e(z)$ measurements as well. Implications for the calculation of conductance from such 2-band LBH images will also be discussed.

Lummerzheim, D. and J. Lilensten, Electron transport and energy degradation in the ionosphere, *Ann. Geophys.*, 12, 1039, 1994

Vondrak, R. R. and M. J. Baron, Radar Measurements of the latitudinal variation of auroral ionization, *Radio Sci.*, 11, 939, 1976.

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Comparing POLAR UVI imager data and other conductance sources in AMIE

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The Assimilative Mapping of Ionospheric Electrodynamics (AMIE) procedure requires information about the instantaneous distribution of ionospheric conductances in order to relate observed magnetic perturbations to the estimated pattern of high-latitude ionospheric electric fields. In the past, most of the conductance information for AMIE came from empirical models, locally modified by available observations of auroral precipitation from DMSP and NOAA satellites and by estimates derived from ground magnetometer data. Recently, POLAR UVI images using two filters have allowed estimates of auroral energy fluxes, mean electron energies, and associated Hall and Pedersen conductances over the entire northern auroral oval. For May 19-20, 1996, we compare the precipitation and conductance estimates derived from UVI data with those based on other data sources, as they influence the estimates of ionospheric electrodynamic parameters in AMIE. The UVI data result in larger estimates of the hemispheric power of precipitating auroral electrons, and hence larger conductances, as well as somewhat smaller polar-cap potential drops and reduced Joule heating. There are also considerable changes in the estimated nightside ionospheric currents and field-aligned currents.

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